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Structural and Optical Properties of $Zn_{1-x}Ni_xO$ Nanoparticles Synthesized by Co-precipitation Method

A. Benazir[1], K. Gomathi[2], S. Aram[3*],

[1,2]PG Student, Sri GVG Visalakshi College for Women, Udumalpet, TN, India.
[*3]Department of Physics, Sri GVG Visalakshi College for Women, Udumalpet, TN, India.

Abstract

Recently Ni doped Zinc Oxide Nanoparticle has worldwide research interest because it is considered a promising material for gas sensors. Although ZnO is one of the earliest discovered semiconducting Oxide gas sensing material. Nanocrystals of undoped and Nickel doped Zinc Oxide were synthesized by Co-precipitation Method. The Structural and morphological Properties were determined by X-Ray Diffraction Technique and Scanning Electron Microscope. The average particle size was determined from X-ray line broadening. X-ray study revealed that Ni doped ZnO crystal is hexagonal wurzite structure. The size of the particle depends on the dopant. The crystalline size of Nanocrystals varied from 11 to 16 nm as the calcinations temperature increased. The optical absorption of Ni doped ZnO indicated that it can be used as an efficient photo catalyst under visible light irradiation. The optical property is analyzed by photoluminescence analysis. It reveals that the emission wavelength and corresponding band gap energy is found to be 576 nm and 2.12 ev respectively. Another sharp peak is observed and it is in the wavelength of 584 nm and band gap energy is 2.15 ev and emits light in the region of yellow visible spectrum.

Keywords: *Co precipitation; Gas Sensor; Photoluminescence; ZnO Nanoparticle.*

1. INTRODUCTION

Synthesis of size and shape controlled metal oxide nanostructures is very important in controlling their physical and chemical properties, and crucial for their potential uses. Recently, considering the properties of the materials are greatly affected by their morphologies, wide range of metal oxide with different morphologies providing great opportunities for the discovery of new properties and potential uses have been synthesized via different methods. Among these methods, simple solution method has great advantages in synthesizing metal oxide through relative low temperature and simple equipment, which makes the method more suitable and economic for large scale production. In order to control the morphology of ZnO nanoparticle, organic additives: such as PVP, PEG, SDS and CTAB, were commonly introduced into the reaction system to manipulate the nucleation and growth in hydrothermal reactions. However, it still remains a challenge to understand their precise working mechanism in directing the growth of ZnO.

The metal oxide, ZnO has a wide band gap (3.37eV) and large exciton binding energy of 60meV. Therefore, it is a promising material for the fabrication of optoelectronic devices operating in the blue and ultraviolet (UV) region. Moreover, due to its superior conducting properties, ZnO has also been investigated as a transparent conducting and piezoelectric material for use as electrodes, catalysts and sensors. It is well known that the changes in optical, electrical, and magnetic properties could occur when impurities are added into a wide band gap semiconductor, thus doping a certain element into ZnO has become an important route to optimize its optical, electrical, and magnetic performance. It was reported that transition-metal (TM)-doped ZnO would be a good candidate to achieve Curie temperature above room temperature, and great efforts have been devoted to the investigation of magnetic metal/ ZnO materials. Ni is an important dopant in these magnetic materials. Furthermore Ni_2 (0.69 A°) has the same valence as Zn_2 and its radius is close to that of Zn_2 (0.74 A°), so it is possible for Ni_2 to replace Zn2 in ZnO lattice. Some researches on Ni doped ZnO have been reported and several results showed that the luminescence properties of ZnO were changed after doping of Ni.

Recently zinc oxide has attracted worldwide research interest because it is considered a promising material for thin film gas sensors in electronic noses. Although ZnO is one of the earliest discovered semiconducting oxide gas sensing materials and there are many reports concerning the sensitivity properties of ZnO, In recent years, there appeared many publication on ZnO nanoparticles, thin film gas sensors using various synthesis techniques including molecular beam

S. Aram
email: benazirphy24@gmail.com

epitaxy, Coprecipitation, chemical vapor deposition, sputtering, thermal evaporation, and reactive vapor deposition. Semiconducting oxide sensors have been used for a few decades for low-cost detection of combustible and toxic gases. However, the sensitivity, selectivity, and stability have limited their use, often in favor of other more expensive gas detection instruments.

2. SYNTHESIS OF PURE/Ni DOPED ZnO NANOPARTICLE

2.1 Synthesis of pure ZnO nanoparticle

A 2.1703gm of Zinc acetate is mixed with solvents of 50 ml of Ethanol and 50 ml of distilled water and stirred by using for magnetic stirrer at temperature of 60°C stirring 1 hour under the pure condition and 1 gm of PVP (Polyvinyl Pyrrolidone) is added with under the stirring condition of Zinc acetate. Then 0.2 gm of NaOH solution is poured with the above solution. After poured NaOH solution the complete solution will be stirred for one hour. Finally, a white colour precipitate is formed.

2.2 Synthesis of ni doped ZnO nanoparticle

A 0.02195 gm of Nickel acetate is mixed with 25 ml of distilled water stirred by using of magnetic stirrer. Zinc acetate and nickel acetate is mixed with each other and 1 gm of PVP is added, again stirred its solution. Then 0.2 gm of NaOH solution is poured drop by drop. A clear densed solution is settled and washed with Ethanol. A solution is drained by using of Hot air oven at temperature of 100 °C. After drained, the white colour densed powder is extracted. Then sample is anneled by using the muffle furnace at temperature of 300 °C. This temperature is maintained for 1 hour and cooled at room temperature.

3. STRUCTURAL PROPERTIES

3.1 XRD Analysis

Fig. 1(a, b & c) shows the XRD diffraction pattern of undoped and Nickel doped ZnO powders. All the diffraction peaks at angles (2θ) of 20-90 degrees correspond to the reflection from (1 0 0), (0 0 2), (1 0 1), (1 0 2), (1 1 0), (1 0 3) and (2 0 0) crystal planes of the hexagonal wurzite ZnO structure. The measured d-spacing of 2.84760, 2.63079, 2.50128, 1.92401, 1.63336, 1.48391, 1.41270 A° also correspond to reflection from above mentioned crystal planes of the wurzite structure. All the diffraction peaks agreed.

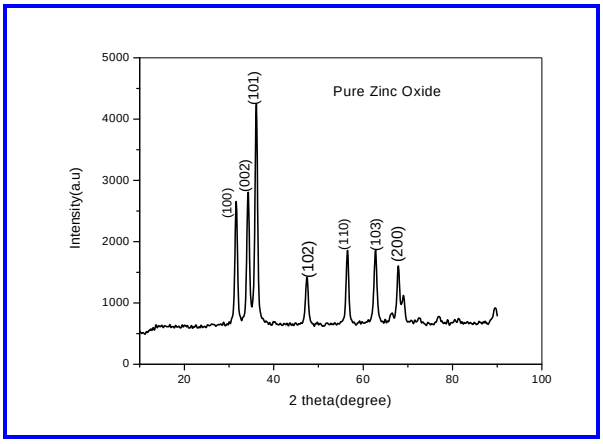

Fig. 1 (a): XRD Pattern of Pure ZnO

No additional peaks corresponding to the secondary phases of Nickel Oxide, which indicates that the Wurzite structure is not disturbed by the Ni substitution. But the (200) plane disappeared and a new peak corresponding to (112) plane is found to substituted in more number on the surface of ZnO.

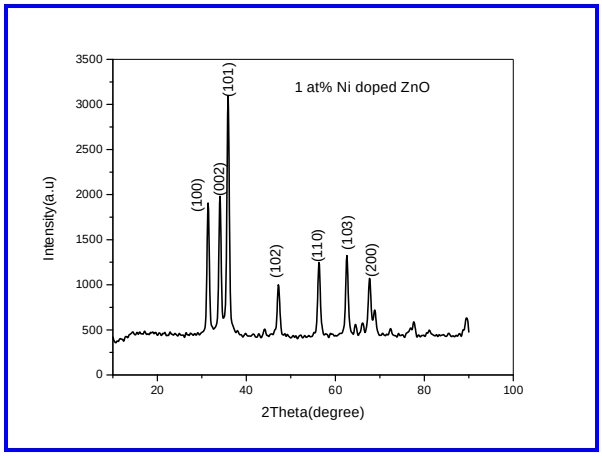

Fig. 1 (b): XRD Pattern of 1 at % Ni doped ZnO

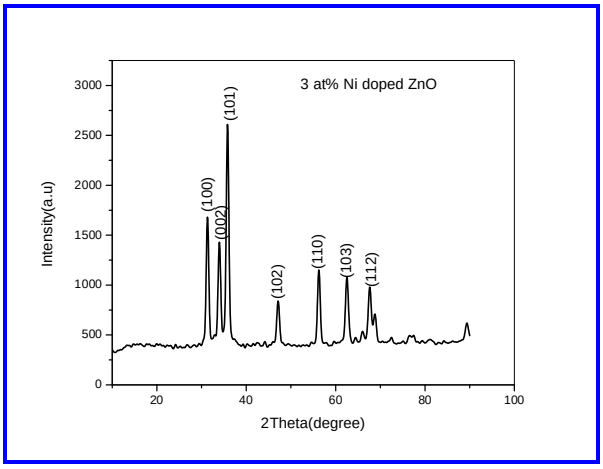

Fig. 1 (c): XRD Pattern of 2 at % Ni doped ZnO

3.2 Scanning electron microscope (SEM) analysis

The morphological studies were carried out by SEM technique. The fig. 2(a) and 2(b) shows the pure and Ni doped ZnO nano particles respectively. The SEM micrograph of pure ZnO nano particle reveals that the particles are aggregated and formed a cluster like shape. In the case of Ni doped ZnO nano sample the particles were tend to aggregate more and formed a even more bigger cluster like shape. It also shows that the ZnO nanoparticles were well dispersed and agglomerated [3]. Due to this the particle size is found to increase when the two samples were compared which is in good agreement with the XRD results.

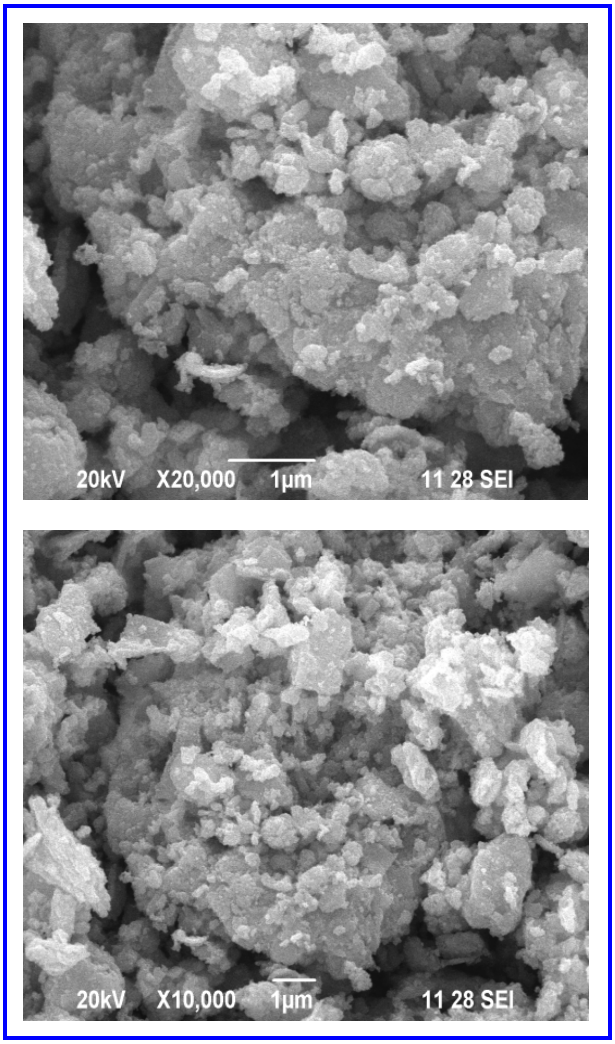

Fig. 2(a&b): SEM image of 1% and 2% Ni doped ZnO

3.3 Photoluminescence (PL) spectra

The optical properties is analysed by photoluminescence analysis. Fig. 3(a) shows the PL spectra of Ni doped ZnO nano material. The fig. 3(a) indicates that the first emission peak is found to be a sharp intense peak which emits light at 567nm. The band gap for this peak is 2.19eV. The next peak is a little broader one. The emission wavelength and corresponding bang gap energy is found to be 576 nm and 2.12eV respectively. There is another sharp peak is observed and it is in the wavelength of 584nm and band gap energy is 2.15eV and emits the light in the region of yellow visible spectrum.

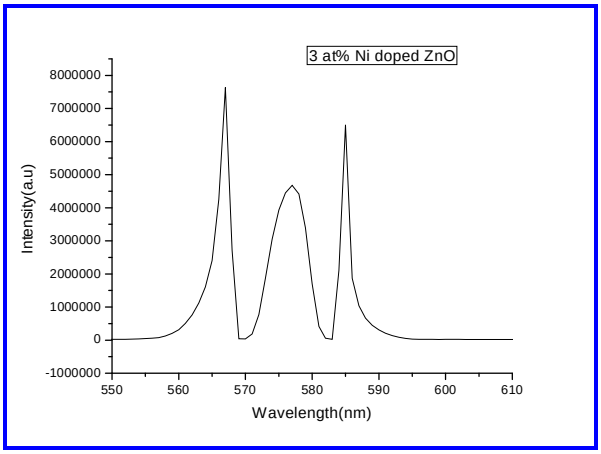

Fig. 3(a): PL spectra for Ni doped ZnO

4. CONCLUSION

Nano crystals of undoped and nickel doped ZnO were successfully synthesized by using a chemical co-precipitation method. The crystalline structure, morphology, composition and optical properties were analysed by XRD,SEM, EDAX and PL spectra.XRD analysis shows that the prepared samples are in hexagonal wurtzite phase. The grain size is calculated using Debye scherrer formula and it is found to be increased for the Ni doped ZnO sample when compared with undoped ZnO sample. This may be due to the doping of Ni in the ZnO sample. The lattice parameter is found to be in good agreement with the JCPDS data. The SEM micrographs shows that the particle size of the Ni doped ZnO sample is larger than the undoped ZnO sample. The PL spectra of the Ni doped ZnO sample shows three emission peaks at different wavelength. The band gap energies are calculated for the respective peaks.

5. SCOPE FOR THE FUTURE WORK

a. The doping material and concentration of the Ni can be varied.
b. The temperature of the sample can be varied.
c. The optical absorption spectra can be studied UV visible and using FTIR.

d. Electrical conductivity and the resistivity of the sample can be analyzed.

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